Innovative Sensor Technology
physical. chemical. biological.

LFS1K0.1305.6W.C.010-6

Conductivity Sensor

For various conductivity measurement applications

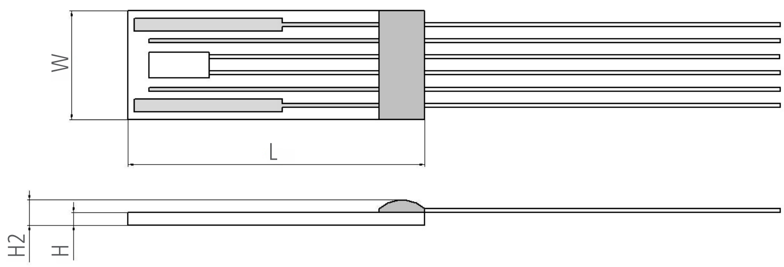
Benefits & Characteristics

- Wide conductivity and temperature range
- Fast response time
- Optimal accuracy
- Resistance to various chemicals[1)]
- Excellent long-term stability
- Integrated RTD for temperature measurement and / or compensation
- 4 electrode measurement[2)]

1) Aggressive media can influence the long term stability. Chemical resistance of the sensor in the end application must be tested by the customer

2) 2 electrode configuration available upon request

Illustration[3)]



3) For actual size, see dimensions

Technical Data

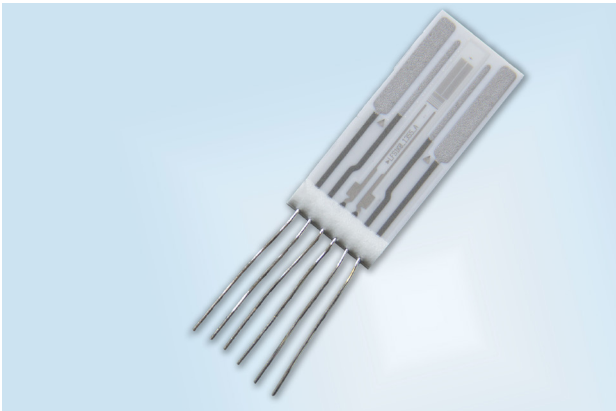
Conductivity range:	100 µS/cm to 200 mS/cm
Cell constant[4)]:	typical 0.86 cm^{-1}
Nominal resistance:	1000 Ω at 0 °C
Measurement frequency range:	100 Hz to 10 kHz
Maximum excitation voltage (between pin 1 and pin 6):	< 0.7 Vpp (Electrolysis of the analyte has to be avoided)
Operating temperature range:	-30 °C to +100 °C
Temperature sensor:	Pt1000
Temperature coefficient (Pt1000):	3850 ppm/K
Measuring current (Pt1000)[5)]:	0.3 mA
Temperature sensor accuracy (dependent on temperature range):	IEC 60751 F0.6 C (IST AG reference)
Connection:	Pt/Ni wires, Ø 0.2 mm
Dimensions (L x W x H / H2 in mm):	12.9 ±0.3 x 5.5 ±0.3 x 0.65 ±0.1 / 1.2 ±0.3

Temperature dependence of resistivity:	according to IEC 60751:
-50 °C to 0 °C	$R(T) = R_0 \times (1 + A \times T + B \times T^2 + C \times (T-100) \times T^3)$
0 °C to 150 °C	$R(T) = R_0 \times (1 + A \times T + B \times T^2)$
	A = $3.9083 \times 10^{-3} \times °C^{-1}$
	B = $-5.775 \times 10^{-7} \times °C^{-2}$
	C = $-4.183 \times 10^{-12} \times °C^{-4}$
	R_0 = resistance value in Ω at T = 0 °C
	T = temperature in accordance with ITS90
Storage temperature:	-20 °C to +100 °C

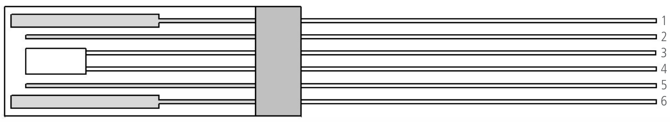
4) Cell constant is strongly affected by external objects coming close to the front surface of the sensor

5) Self heating must be considered

Product Photo:



Pin Assignment



1	2	3	4	5	6
I_2	V_2	T_2	T_1	V_1	I_1

I: applied current V: measured voltage T: temperature sensor

Order Information

Description:	Item number:	Former main reference:
LFS1K0.1305.6W.C.010-6	103851	090.00073

Application Note
LFS Sensors

1. LFS

1.1 About the sensor

Conductivity is a measurement of the ion concentration in a solution. It can be used to determine the quality, the amount of nutrients, salts or impurities in water or aqueous solutions. The temperature sensor on the device allows temperature measurement and compensation. It is placed directly in the measurement area to improve accuracy.

Despite its simplicity, the measurement of electrical conductivity in liquid substances is a very powerful analytical and diagnostic tool in a variety of applications. The modern, thin-film conductivity sensor element is a viable alternative to the classical, bulky conductivity sensors of the past.

Based on thin- or thick-film technology, conductivity sensors can be developed and produced with customer specific requirements. Enhanced application integration is possible by directly manufacturing the sensor with custom housing and specific connections.

1.2 Benefits and Characteristics

The following list showcases the advantages the LFS conductivity sensor has. It is not a list of the sensor's full range of capabilities and should not be seen as such.

- Wide conductivity and temperature range
- Fast response time
- Optimal accuracy
- Resistance to various chemicals[1)]
- Excellent long-term stability
- Integrated temperature measurement
- 2 or 4 electrode measurement
- Customer specific sensor available upon request

1) Aggressive media can influence the long-term stability

1.3 Application areas

Among other, the LFS conductivity sensor is suitable for, but not limited to, the following application areas:

- Process Control and Automation
- Wastewater treatment
- Handheld Devices
- Medical
- Biotechnology
- Soil Treament

1.4 Sensor structure

The following paragraphs describes and elaborates the multiple steps of the sensor structure.

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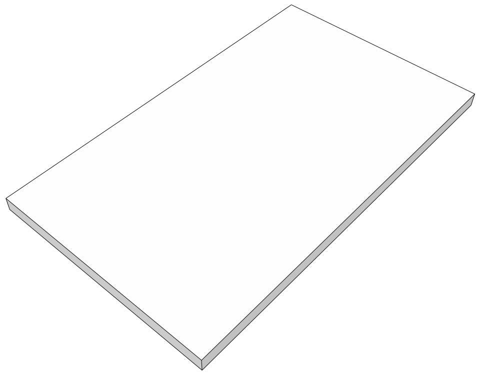
Substrate

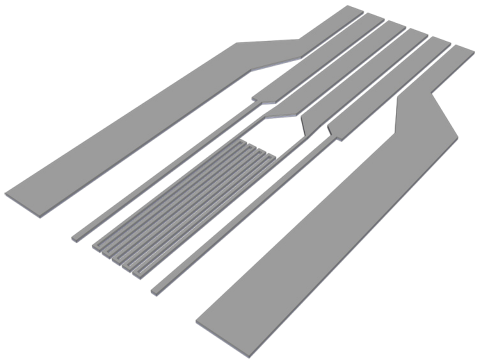


The base of the LFS conductivity sensor chip is a special ceramic with low thermal conductivity.

The production of the LFS conductivity sensor starts by deposition of high purity platinum thin film layers onto the ceramic substrate.

To ensure high quality sensors, wet chemical processes are performed on automated systems for chemical cleaning and etching processes.

Resistive Structure

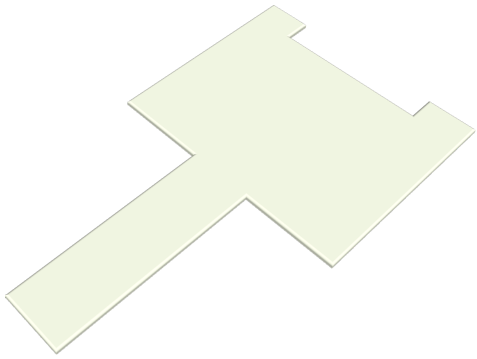


The resistive structure on the sensor consists of two current electrodes (Pt) and two measuring eletrodes (Pt) available in either thin or thick film technology. Additionally, an integrated Pt RTD temperature sensor (Pt100/Pt1000) is placed directly between the measuring electrodes for an optimal temperature compensation.

The resistive structure is fabricated by multiple steps, hereunder spin
coating of a photo-sensitive resist, illumination of the photo sensitive resist through a mask, developing the photo resist and etching the platinum, leaving only the sensor structure on the chip.

Finally, the sensor is individually laser trimmed to the customer specific resistance.

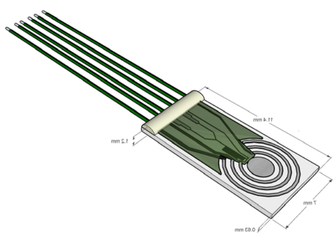
Passivation



The integrated temperature sensor is covered with a glass passivation
using screen printing, which prevents mechanical damage and furthermore increases the robustness and strength.

Afterwards each substrate is diced on fully automated dicing machines and ready for wiring.

Wire Connections



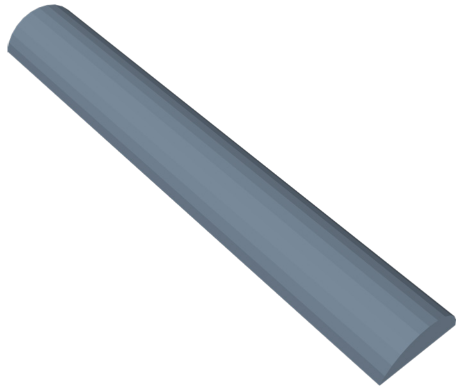
The LFS conductivity sensor is equipped with wire connections welded on the chip on automated welding machines.

For easy to use design-in the sensor can be ordered with various customer specific lengths, requirements and specifications.

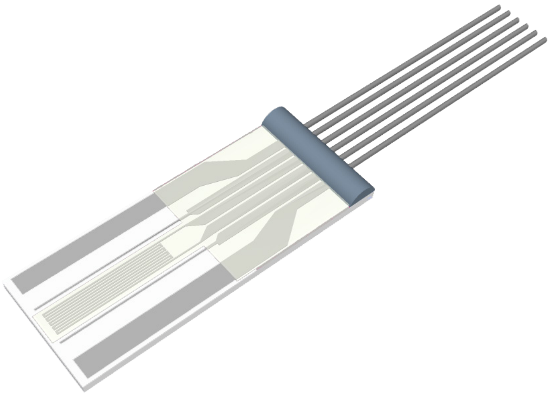
The standard LFS conductivity sensor is delivered with either Pt/Ni wires, Ø 0.2 mm, 10 mm long or Cu/Ag wires, PTFE insulated, AWG 30, 5 mm stripped and suitable for crimping and attaching connectors.

Wire Fixation

The welding area is additionally covered by a polymide to increase robustness, resulting in a pull strength of 10N and best possible mechanical robustness.



Final Sensor Layout



1.5 Measurement principle

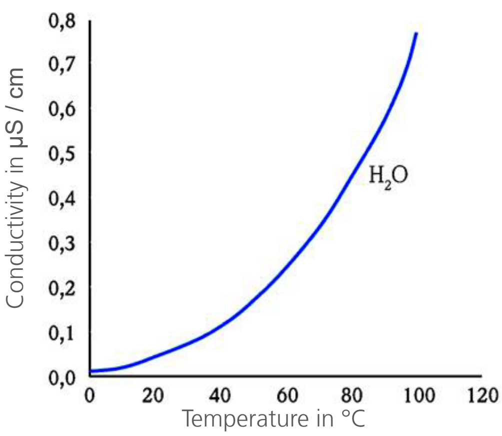
An electrolyte is a liquid substance, which contains ions. The conductivity of a liquid depends on two temperature dependent parameters: ion concentration and their mobility.

When an electrical voltage is applied between two electrodes, an electric current flows between these electrodes due to the ions. The voltage drop over the electrolyte is an indicator for the conductivity. (4 leads measurement principle).

The conductivity of an electrolyte is strongly dependent on temperature. The higher the temperature is, the higher is the conductivity of the electrolyte. Therefore a temperature sensor (Pt100 or Pt1000) is added on the sensor for compensation and improved accuracy directly at the point of measurement.

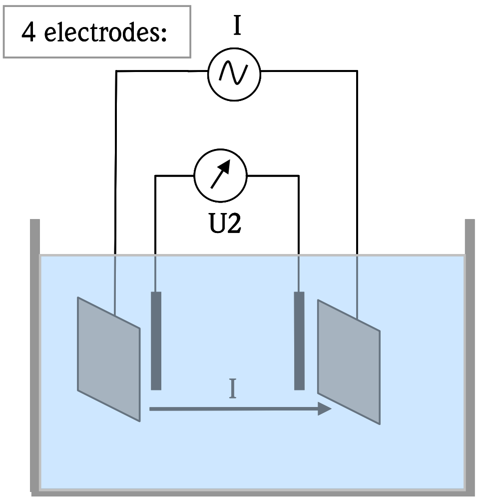
Electrolytes have a negative temperature coefficient: The conductivity increases with the temperature.

The IST AG LFS conductivity sensors are working based on the conductive measurement principle.

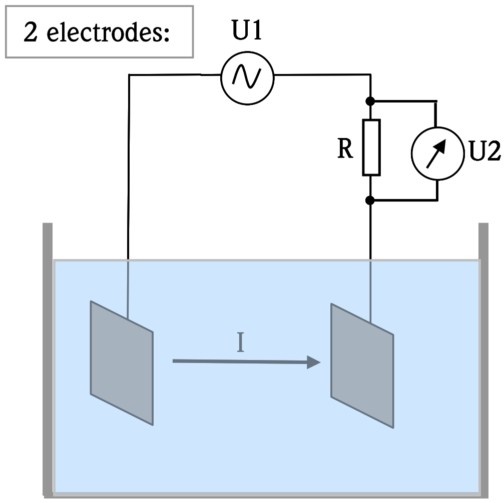


Conductivity (using electrodes)

4 electrodes



2 electrodes



AC excitation is recommended to reduce degradation of the electrode and electrolyte.

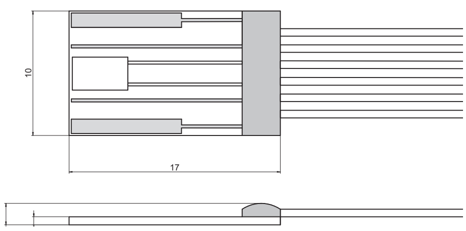
U1 = input signal (AC)
U2 = output signal (AC)
I = current flow
R = resistor

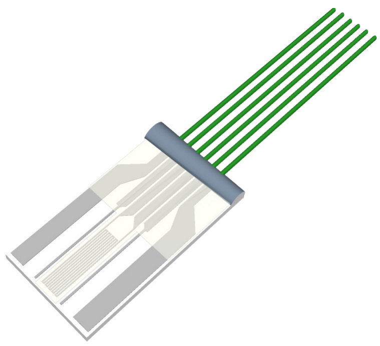
1.6 Dimensions and Housing

The following describes the dimension of the standard Innovative Sensor Technology IST AG LFS conductivity sensor.

LFS 117

The dimensions of the standard sensor are 16.9 x 9.9 x 0.65 / 1.2 (L x W x H / H2 in mm). This does not include housing or connecting wires.

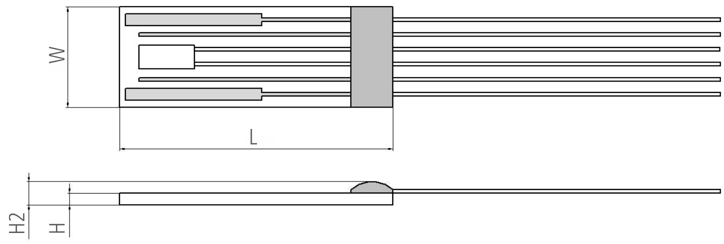


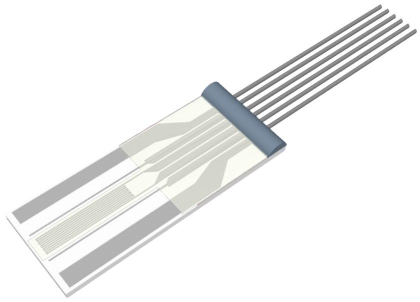


The standard IST AG LFS 117 conductivity sensor is available with either Pt/Ni wires, Ø 0.2 mm, 10 mm long or Cu/Ag wires, PTFE insulated, AWG 30.

LFS 155

The dimensions of the standard sensor are 14.9 x 5.5 x 0.65 / 1.2 (L x W x H / H2 in mm). This does not include housing or connecting wires.





The standard IST AG LFS 155 conductivity sensor is available with either Pt/Ni wires, Ø 0.2 mm, 10 mm long or Cu/ Ag wires, PTFE insulated, AWG 30.

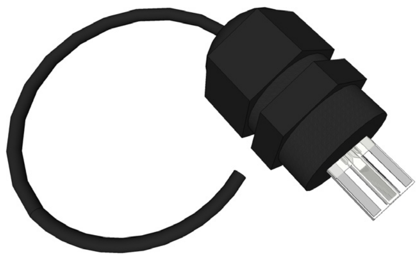
If you have any questions regarding specific housing possibilities, please contact us to find the best possible solution for your application.

1.7 Mounting

The following mounting possibilities serve as inspiration, only. If you have any questions regarding specific mounting possibilities, please contact us to find the best possible solution for your application.

Customized over-mold

The LSF conductivity sensor can be mounted in a custom over mold housing.



1.8 Delivery and Content

The standard delivery time of the standard Innovative Sensor Technology IST AG LFS conductivity sensor is 4-6 weeks after order receival.

The sensor must be stored between -20 °C to +150 °C.

The LFS conductivity is delivered without electronic parts or modules.

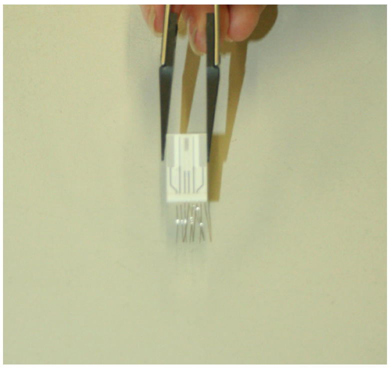
1.9 Handling

The LFS sensor is delivered in a carton box and must be handled as follows:

The LFS sensor is delivered in a blister with label showing the exact sensor type and lot-number

Open the blister carefully with both hands

Remove the stripes of plastic covering the sensors

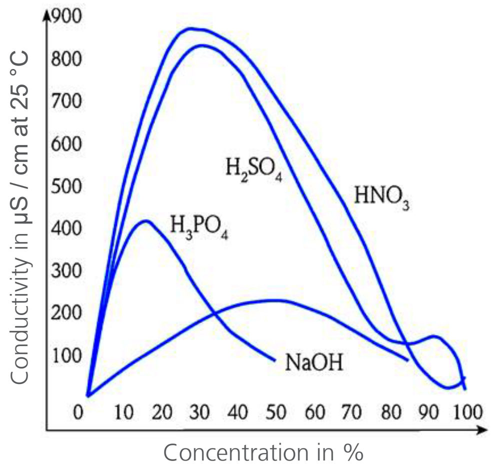


Handle the sensors with plastic tweezers only

1.10 Performance

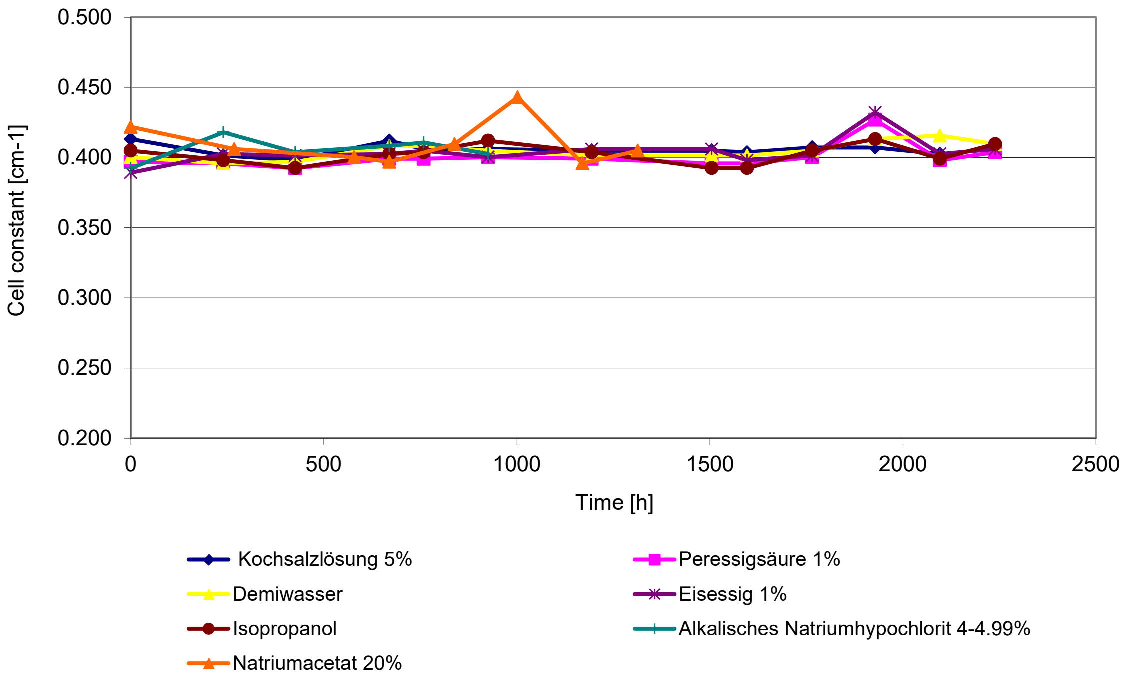
The following graphs showcases the performance of the IST AG LFS sensor during application. Depending on the application and possible influences the measurements might vary.

Electrolyte	Electrical conductivity	
	µS/cm	S/m
Ultra pure water	0.05 - 0.1	5-10 * 10^{-6}
Tap water	300 - 800	0.03 - 0.08
NaCl (0.2 g/l)	4000	0.4
NaCl (2 g/l)	38600	3.86
Seawater	~ 56000	~ 5.6
Bulk silver (for comparison)	62.5*10^{6}	6250



Stability

- Sensors exposed to different solutions over 2200 h (~3 months)
- Cell constant measured in standard conductivity solution (1413 µS/cm)



1.11 Influence

Composition of electrolyte and temperature

The conductance depends on the composition of the electrolyte and the temperature (integration of a temperature sensor (Pt100 or Pt1'000) on the chip).

Specific electric conductance of an electrolyte:

$$\alpha = \kappa \quad \frac{I}{U} \quad \frac{L}{L + (\alpha / 100) * (T - 25)}$$

Cell Constant

The conductivity value, as a result of the measurement, depends additionally on the cell geometry. The influence of the cell geometry can be eliminated by introducing the so-called cell constant. Using the following formula, the electrical conductivity, κ, can be obtained at a specific temperature.

The IST AG LFS conductivity sensors have a cell constant of ~0.4 cm^{-1}

$$\kappa = \frac{k * I}{U}$$

$$R = \frac{L}{\kappa * A}$$

$$\rightarrow \kappa = \frac{L}{R * A}$$

The exact value of the cell constant can be obtained as a result of calibration measurements in standard solutions. To avoid additional measurement errors, it is important to use a solution with electrical conductivity values close to the values of the intended application solution.

σ	= Specific electric conductance [S / cm]
α	= Temperature compensation (~2.5 % / °C)
T	= Measured temperature [°C]
k	= Cell constant
U	= Measurement voltage
I	= Current flow
κ	= Electrical conductivity
U1	= Input alternating voltage
U2	= Output alternating voltage
p	= Electrolyte resistance
R	= Resistance
L	= Length
A	= Area

The cell constant can be adapted as a function of the customer requirements (mainly the conductivity of their electrolyte):

- Low conductivity ↔ Low cell constant
- High conductivity ↔ High cell constant

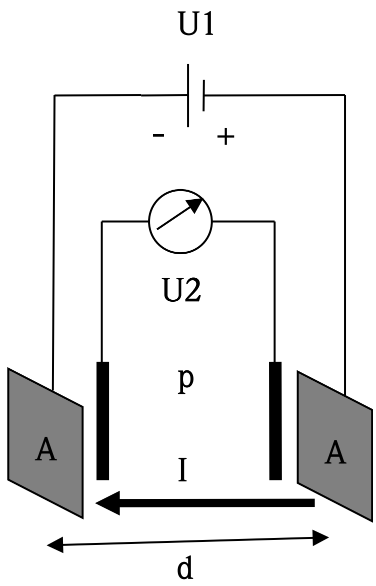
The cell constant can be changed by changing the distance between the electrodes or the size of the current electrodes:

L increases → k increases

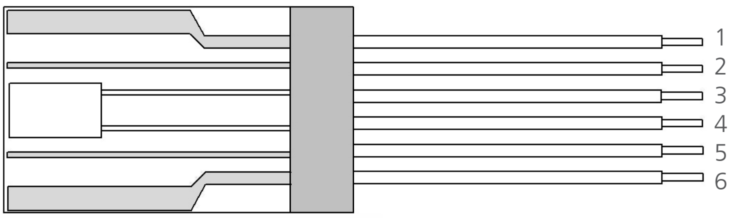
A increases → k decreases

Cell constant is influenced by:

- Boundary effects
- Planar geometry of chip layout



1.12 Electronic and Circuit Diagram



1	2	3	4	5	6
I2	V2	T2	T1	V1	I1

I: applied current V: measured voltage T: temperature sensor

Applied voltage for conductivity measurement

For the measurement, an alternating voltage must be applied.

Recommended voltage: 0.7 V_{AC}

Measuring frequency for conductivity

A suitable range of value is: 300 – 3000 Hz

Failure of polarization

To avoid polarization failure, it is important to:

- Use alternating measurement voltage
- Use 4 leads measurement principle

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